The Modern Phorometer

De Zeng

WHAT A FRIEND!

Tunes—"What a Friend!" 161; "Life's Morn," 172. S. B., 513.

1. What a Friend we have in Jesus,
All our sins and griefs to bear!
What a privilege to carry
Everything to God in prayer!
Oh, what peace we often forfeit,
Oh, what needless pain we bear—
All because we do not carry
Everything to God in prayer!

2. Have we trials and temptations?
Is there trouble anywhere?
We should never be discouraged:
Take it to the Lord in prayer!
Can we find a friend so faithful,
Who will all our sorrows share?
Jesus knows our every weakness—
Take it to the Lord in prayer!

3. Are we weak and heavy-laden,
Cumbered with a load of care?
Precious Saviour, still our Refuge—
Take it to the Lord in prayer!
Do thy friends de[illegible]se, forsake thee?
in prayer!
ke and shield thee,

Relation Between Visual Acuity and Visual Efficiency.

By Scott Sterling and A. C. Snell.

Snellen notation.	Visual angle in minutes.	Visual efficiency in per cent.	Percentage loss of vision.
20/20	1.0	100.0	0
20/25	1.25	95.6	4.4
20/30	1.50	91.4	8.6
20/40	2	83.6	16.4
20/50	2.5	76.5	23.5
20/60	3	69.9	30.1
20/70	3.5	63.8	36.2
20/80	4	58.5	41.5
20/90	4.5	53.4	46.4
20/100	5	48.9	51.1
20/120	6	40.9	59.1
20/140	7	34.2	65.8
20/160	8	28.6	71.4
20/180	9	23.9	76.1
20/200	10	20.0	80.0
20/220	11	16.7	83.3
20/240	12	14.0	86.0
20/260	13	11.7	87.3
20/280	14	9.8	90.2
20/300	15	8.2	91.8
20/340	17	5.7	94.3
20/380	19	4.0	96.0
20/400	20	3.3	96.7
20/500	25	1.1	98.9
20/600	30	0.6	99.4
20/800	40	0.1	99.9

The visual efficiency of an eye is defined as the ratio of its resolving power to the resolving power of the normal eye.

lowing facts bear some analysis:

1.—*An eye before which is placed a prism turns in the direction of the APEX*. (This rule is worth remembering.)

The particular value in knowing the above fact, and in remembering it as well, will become apparent as we continue our discussion.

2.—*Light passing through a prism is deflected or bent toward the BASE.*

With the second fact as to the prism's influence upon transmitted light, a property explained wholly upon the simple laws of refraction, we are in a position now to explain rationally why "an eye before which is placed a prism will turn inevitably in the direction of the *apex*."

FIG 1

In figure 1 is presented an eye, before which is placed a prism with apex in the direction indicated. We will assume that the eye substance as well as the prism is utterly transparent so that we can view the fundus and behold the altered position of an image as affected by the influence of the prism.

F is the fovea, and A an object from which rays are directed toward the fovea. The prism intercepts all light waves entering the eye, deflecting them as they leave the prism (at the point D, for instance) and enter the eye in the direction of the base of the prism. An image that would have formed upon the fovea F is thereby placed at the point I on the portion of the retina over which is the *base* of the prism.

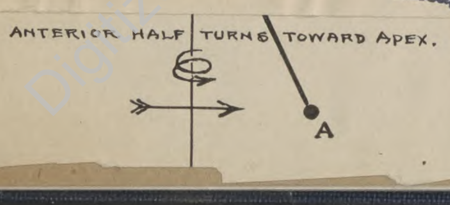
In the interest of keener vision the eye will now rotate so that the fovea, F, may receive the image situated at I. F and I are both on the posterior side of the globe. As the posterior pole of the eye

get these fundamental truths:

3.—*The APEX of a prism before a lateral or vertical muscle will cause that muscle to CONTRACT*. (This is true in a broad sense.)

4.—*The BASE of a prism before a lateral or vertical muscle will cause that muscle to RELAX.* (This is also true in a broad sense.)

The al—



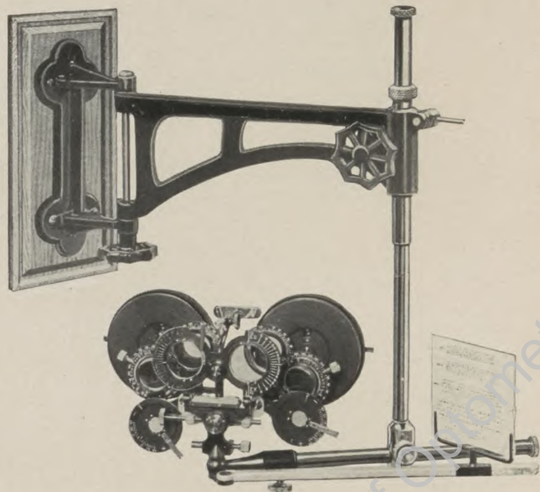
by these prismatic effects,

TABLE OF BIFOCAL INSETS

for 16″ Reading Distance
Showing Amount of Inset Required for each Bifocal Segment to make Reading Fields Coincide at 16″ Reading Distance

Power of Distance Lenses	Distance from center of nose to center of pupil when eyes are adapted to distance vision									
	27	28	29	30	31	32	33	34	36	36
+15.00	2.5	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3
+14.00	2.4	2.5	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2
+12.00	2.2	2.3	2.4	2.5	2.5	2.6	2.7	2.8	2.9	3.0
+10.00	2.1	2.2	2.2	2.3	2.4	2.5	2.5	2.6	2.7	2.8
+ 9.00	2.0	2.1	2.2	2.2	2.3	2.4	2.5	2.5	2.6	2.7
+ 8.00	2.0	2.0	2.1	2.2	2.2	2.3	2.4	2.5	2.5	2.6
+ 7.00	1.9	2.0	2.0	2.1	2.2	2.3	2.3	2.4	2.5	2.5
+ 6.00	1.9	1.9	2.0	2.1	2.1	2.2	2.3	2.3	2.4	2.5
+ 5.00	1.8	1.9	1.9	2.0	2.1	2.1	2.2	2.3	2.3	2.4
+ 4.00	1.8	1.8	1.9	2.0	2.0	2.1	2.1	2.2	2.3	2.3
+ 3.00	1.7	1.8	1.8	1.9	2.0	2.0	2.1	2.2	2.2	2.3
+ 2.00	1.7	1.7	1.8	1.9	1.9	2.0	2.0	2.1	2.2	2.2
+ 1.00	1.6	1.7	1.7	1.8	1.9	1.9	2.0	2.0	2.1	2.2
0	1.6	1.6	1.7	1.8	1.8	1.9	1.9	2.0	2.1	2.1
— 1.00	1.6	1.6	1.7	1.7	1.8	1.8	1.9	2.0	2.0	2.1
— 2.00	1.5	1.6	1.6	1.7	1.7	1.8	1.9	1.9	2.0	2.0
— 3.00	1.5	1.5	1.6	1.6	1.7	1.8	1.8	1.9	1.9	2.0
— 4.00	1.5	1.5	1.6	1.6	1.7	1.7	1.8	1.8	1.9	1.9
— 5.00	1.4	1.5	1.5	1.6	1.6	1.7	1.7	1.8	1.8	1.9
— 6.00	1.4	1.4	1.5	1.5	1.6	1.6	1.7	1.8	1.8	1.9
— 7.00	1.4	1.4	1.5	1.5	1.6	1.6	1.7	1.7	1.8	1.8
— 8.00	1.3	1.4	1.4	1.5	1.5	1.6	1.6	1.7	1.7	1.8
— 9.00	1.3	1.4	1.4	1.5	1.5	1.6	1.6	1.7	1.7	1.7
—10.00	1.3	1.3	1.4	1.4	1.5	1.5	1.6	1.6	1.7	1.7
—12.00	1.2	1.3	1.3	1.4	1.4	1.5	1.5	1.6	1.6	1.7
—14.00	1.2	1.2	1.3	1.3	1.4	1.4	1.5	1.5	1.5	1.6
—16.00	1.2	1.2	1.2	1.3	1.3	1.4	1.4	1.5	1.5	1.5
—18.00	1.1	1.2	1.2	1.2	1.3	1.3	1.4	1.4	1.4	1.5
—20.00	1.1	1.1	1.2	1.2	1.2	1.3	1.3	1.4	1.4	1.4
—22.00	1.1	1.1	1.1	1.2	1.2	1.2	1.3	1.3	1.4	1.4

For distances from 12″ to 16″ add 0.1 mm to amount of inset for each inch of reading distance nearer than 16″ For distances from 16″ to 20″ deduct .1 mm from amount of inset for each inch of reading distance greater than 16″.



The Phoro-Optometer with Wall Bracket

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CONTENTS

PREFACE

WHILE the development which has taken place in ophthalmologic equipment during the last decade has brought much new and improved apparatus into general use, no particular group of instruments have shared in this development more fully than those devoted to muscle testing.

It is therefore in the interest of a wider general knowledge of the modern phorometer and its application that this handbook has been prepared.

CHAPTER I

General Construction of the Modern Phorometer

IN construction, the modern Phorometer proper, embodies in compact and adjustable form, a pair of double rotary prism units of thirty diopters each, mounted in fully graduated supports; a pair of Maddox multiple white rods, each mounted in a graduated support; a Stevens phorometer attachment with spirit level; a near point test, and an adjustable brow rest.

The instrument is, however, rarely supplied in this exact form, owing to the added value of equipment with which an examination of the refraction of the eye can be made, as well as of its motor muscles.

To meet this requirement, a pair of three-cell trial lens holders have been added, thereby making the combined instrument known as the "Phorometer-Trial Frame," shown in Fig. 1.

In still another, and more complete form, the Phorometer proper is combined with an

Optometer, and when made up in this way, is known as the Phoro-Optometer. Such an instrument is shown in Fig. 7.

The body structure of these instruments contains both inter-pupilary and leveling adjustments, also an inter-pupilary scale. The double rotary prism units and the Maddox multiple rods are adjustably mounted on either side, the former immediately in front of the trial lens holders and the latter just behind the Stevens phorometer attachment.

The trial lens holders are stationary, and have a scale for the location of cylinder axis; also two rear cells and a front revolving cell with spring clip and gear drive.

The instruments are supported by either a wall bracket, floor stand or chair fixture which have both coarse and fine adjustments for bringing the instrument into operative place with respect to the position of the observer.

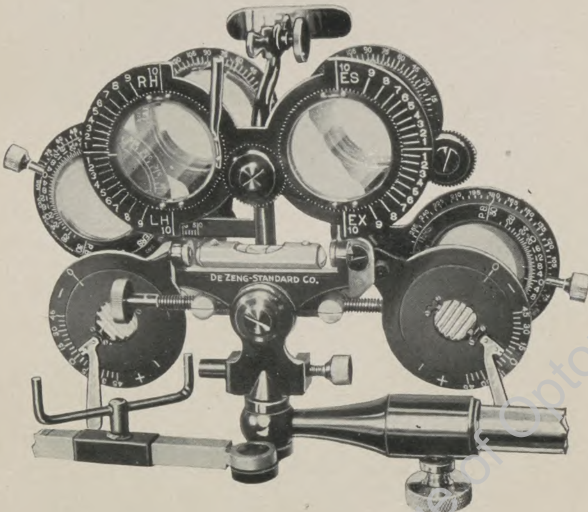


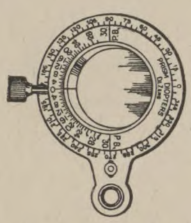
FIG. 1. THE PHOROMETER-TRIAL FRAME

CHAPTER II

The Universal Double Rotary Prism Units

THE universal double rotary prism units described herein, are similar to the Crete or the Risley prisms, and are individually composed of two 15 diopter prisms mounted back to back, each in a separate cell. These cells are provided with gear teeth about their outer periphery which engage a radïal pinion located between them. When all parts are assembled within the circular holder, or prism case, and the pinion is turned, the prisms rotate inversely with respect to each other about a common center. By means of this inverse rotation, the prisms may be so interrelated as to produce any desired prism equivalent ranging in value from zero to thirty prism diopters. When the bases of the prisms are diametrically opposed, as at zero, the system is neutral, and possesses no prismatic value, but when they are at an angle with one another, prism value exists, and the base of the resultant prism equivalent

is always located midway upon the arc of their approach. This would necessarily be at the thirty diopter graduation, marked "P.B." upon the prism case. The more acute the angle between the bases of the prisms becomes as they approach each other, the greater the resultant prism equivalent will be, as shown by the position of the indicator with respect to the prism dioptric scale engraved



DOUBLE ROTARY PRISM UNIT WITH ZERO GRADUATION HORIZONTAL

Fig. 2

DOUBLE ROTARY PRISM UNIT WITH ZERO GRADUATION VERTICAL

Fig. 3

on the face of the prism case. The complete prism unit is rotatably mounted in a fully graduated support, and by means of two peripheral indicators co-acting therewith, the base of every prism equivalent obtainable can be located on any meridian of the circle, thereby giving the prism unit universal adaptability. The arm of the support has an adjustable stop for bringing the prism unit

to exact alignment when placed in operative position upon the phorometer.

The prisms function as follows:—With zero graduation horizontal and indicator set therewith, as shown in Fig. 2, a rotation of the indicator upward to 8 upon the scale would give the equivalent of an 8 diopter prism with base up, while a rotation from zero downward to 8, would give the equivalent of an 8 diopter prism with base down. With zero graduation vertical and indicator set therewith, as shown in Fig. 3, a rotation of the indicator outward to 12 upon the scale, would give the equivalent of a 12 diopter prism with base out, while a rotation of the indicator from zero inward to 12, would give the equivalent of a 12 diopter prism with base in. Hence, a rotation of the indicator up, down, in or out, from zero, when same is in either a horizontal or a vertical position, would give a corresponding prism equivalent with base located respectively.

The base of every prism equivalent obtainable with these universal double rotary prism units, is always located on the 30 diopter line of the scale to that side of zero with which the prism indicator is in register.

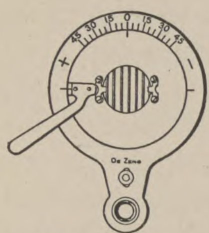
CHAPTER III

The Maddox Graduated Multiple Rods

IN complete form, the Maddox graduated multiple rods individually comprise a small plano corrugated lens mounted in a large flat metal disk with handle and two indicators. The disk is supported in an adjustable holder having a degree scale above, and a minus and a plus character in the upper nasal and temporal quadrants respectively. The arm of the holder is fitted with an adjustable stop for bringing the rod to exact alignment when placed in operative position upon the phorometer.

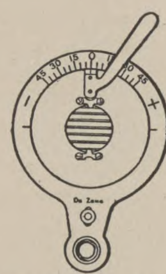
The rod, in effect optically, being that of a number of very strong plano convex cylinders placed side by side, its axis is coincident with its corrugations, and light in passing through it is distributed at right angles therewith. Therefore, with axis vertical (Fig. 4) a distant spot of light viewed through the rod would be transformed into a long horizontal streak of light of same width as the diameter of the spot; whereas with axis horizontal, (Fig. 5) the spot would appear as a vertical streak of light.

If, with axis vertical, the streak should appear other than horizontal, the rod may be rotated for its correction, whereupon the indicator will denote the position of the axis of the rod in degrees of arc on either side of zero. Should the indicator stand opposite



MADDOX GRADUATED MULTIPLE ROD WITH AXIS VERTICAL

Fig. 4.



MADDOX GRADUATED MULTIPLE ROD WITH AXIS HORIZONTAL

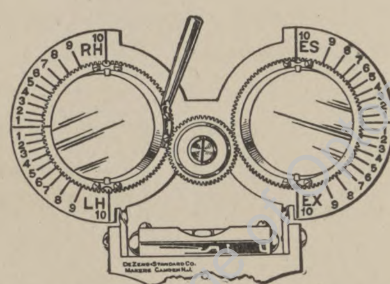
Fig. 5.

the 15 degree graduation in the nasal quadrant, the minus character placed there would indicate a corresponding amount of minus cyclophoria. Should the indicator stand in the same relative position in the temporal quadrant, the plus character stationed there would indicate a corresponding amount of plus cyclophoria. To be of value these multiple rods should be accurately ground on both surfaces and free from any prismatic elements.

CHAPTER IV

The Stevens Phorometer Attachment

THE binocular phorometer attachment of Stevens, contains two 5 diopter prisms mounted side by side, each in a rotatable cell having gear-teeth which engage an intermediate gear-wheel, the whole being support-



STEVENS PHOROMETER ATTACHMENT
WITH INDICATOR AT RIGHT HAND, OR RED, ZERO

Fig. 6.

ed by a broad metal frame, (Fig. 6). This frame is graduated and lettered at either end, and is adjustably connected beneath with a supporting bracket having a spirit level and an adjusting screw. Each prism-cell has an

indicator for its respective scale and one of them carries a handle whereby both may be rotated. Due to the intermediate gear wheel, the rotation of the prisms is relatively inverse, and their bases are thereby so interrelated that both are either in or out simultaneously, or one is up when the other is down.

The graduated scale on the end of the frame to the observer's right, is finished in red, and indicates vertical errors only, the upper quadrant measuring Right Hyperphoria "R.H.," and the lower quadrant Left Hyperphoria "L.H." The scale on the opposite end is finished in white, and indicates lateral errors only, the upper quadrant measuring Esophoria "E.S.," and the lower quadrant Exophoria "E.X." The maximum range of this attachment is 10 prism diopters.

As in the case of the rotary prisms and the Maddox rods, this attachment may be swung out of operative place when not required.

CHAPTER V

The Phoro-Optometer

AS the name implies, the phoro-optometer is an instrument containing both muscle and refraction measuring elements, and in the instrument here shown (Fig. 7) combines the complete phorometer described in Chapter 1, with an optometer having a multiple series of spherical lenses mounted binocularly in light disk form. The disks are compactly attached to either side of the instrument, and positive spring stops insure correct alignment of the lenses which they carry as they are brought routinely into operative position at the sight opening.

By combining the lenses in the different disks (Figs. 8 to 11) any plus spherical equivalent of from .12 to 8. D. is obtainable in eighths, and from .25 to 15.75 D. in quarters on each side of the instrument. The minus spherical equivalents are likewise obtained, although the range in these numbers is extended to 19.75 D. The arrangement of the lenses is such that any desired focal equivalent may be quickly obtained or changed on

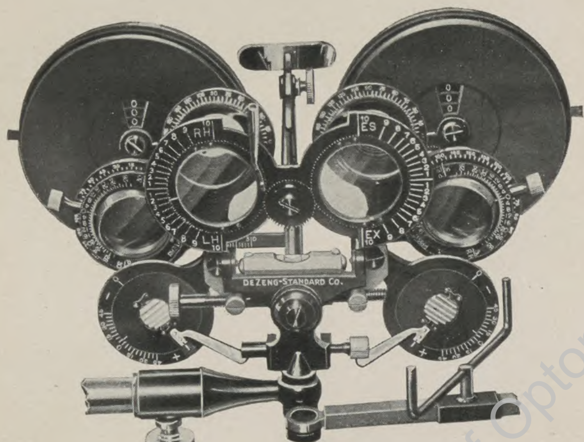
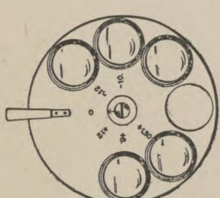


FIG. 7. THE PHORO-OPTOMETER

either side through the independent action of the disks. A total of ninety-five plus and one hundred and nineteen minus numbers may be obtained on either side of the instrument. The lenses are $\frac{13}{16}$ inch in diameter and are protected by metal shields both front and back.

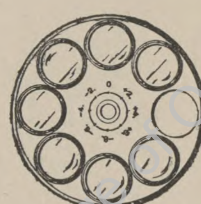
All lenses of high power are carried by the disks nearest to the observer, which brings them close to the eyes under test.

The arrangement of the disks and lenses which they contain is as follows:



FIRST DISK

Fig. 8.

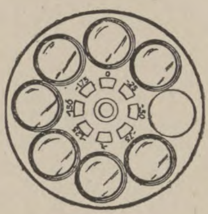


SECOND DISK

Fig- 9.

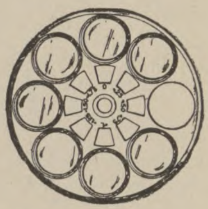
The first disk or the one nearest the observer, on either side of the Phoro-Optometer, is shown in fig. 8. Each disk of this pair contains a zero and the spherical auxiliaries, +.12, +8., −.12, −10. and +1.50 for retinoscopy; also a blank for use as a blinder.

The second disk, on either side of the instrument, is shown in fig. 9. Each disk of this pair contains a zero and the spherical auxiliaries +2., +4., +6.; –2., –4., –6. and –8.



THIRD DISK

Fig. 10.



FOURTH OR FRONT DISK

Fig. 11.

The third disk on either side is shown in fig. 10. Each disk of this pair contains 0, –.25, –.50, –.75, –1.00, –1.25, –1.50 and – 1.75.

The fourth, or front, disk on either side is shown in fig. 11. Each disk of this pair contains 0, +.25, +.50, +.75, +1.00, +1.25, +1.50 and +1.75.

CHAPTER VI

Method of Application

PLACE the instrument in position before the observer when comfortably seated in direct vertical and horizontal alignment with the distant test object, and adjust the brow rest and pupilary slides to their respective requirements, also the spirit level to horizontal balance. Remove the Stevens phorometer attachment, the Maddox rods, and the double rotary prism units from operative place; the first named attachment folding forward and down while the others swing outward and down to right and left.

Conduct the tests for errors of refraction in the usual manner, employing the customary test types, which should be well illuminated. When testing or exercising the muscles, employ the dark room and use an adjustable light spot as the test object, which should be located five or six meters distant and in direct vertical and horizontal alignment with the phorometer. Should the position of the instrument be altered to any appreciable extent

to meet the requirements of different observers, the position of the test object should be adjusted accordingly, as the accuracy of a muscle test depends largely upon the maintenance of a correct relationship between the test object and the phorometer.

When testing the refraction with the Phorometer-Trial Frame instrument, place trial lenses from the test case in their usual position before the eye; the spherical lenses in the rear cells and the cylinders in the front or revolving cells of the trial frame attachment.

In the Phoro-Optometer the spherical lens attachments obviate the use of these lenses from the test case, and the front or revolving cells for holding the cylinder lenses from the test case, or the rotary cross cylinder, as the case may be, only are supplied.

This instrument is provided with large cupped eye-pieces in lieu of brow rest, which position the eyes correctly during the test.

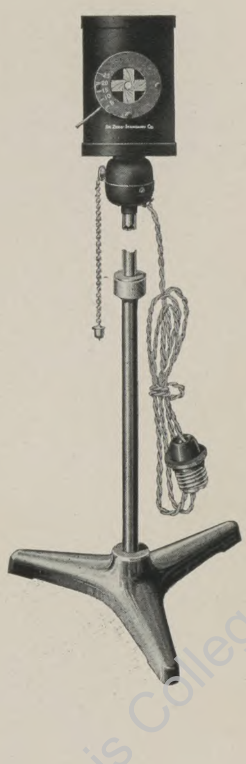


FIG. 12. DARK ROOM LANTERN

DARK ROOM LANTERN

The dark room lantern, devised by the writer, for muscle testing (Fig. 12) contains Ziegler's Greek cross, Thorington's iris diaphragm and a white translucent disk, mounted on an asbestos tube having ventilated end caps. A fully frosted tungsten lamp of 25 watts is mounted within the tube, and when the diaphragm is adjusted to an opening of 10 m|m or less, only a round spot of tempered white light of corresponding size is visible. When the diaphragm is opened to its full extent, the Greek cross only is seen. A three point lens holder is attached to the front of the diaphragm for supporting a colored glass disk or an auxiliary lens if desired. The lantern is adjustably mounted on a light floor stand and has cord conductors with socket tap for making electrical connection.

CHAPTER VII

Binocular Test of the Recti Muscles

Employing a Maddox Multiple Rod, Stevens Phorometer Attachment, Dark Room and Small Luminous Test Object.

THE binocular test of the recti muscles is conducted as follows:

Adjust the phorometer to the required position, as explained in Chapter VI, and should the observer be ametropic, place an accurate and well centered correction for the error in position before beginning the muscle test.

To test the muscular balance vertically by means of this binocular method, darken the room and place a Maddox multiple rod in operative position with axis vertical, (Fig. 4) before the left eye. Employ as a test object a round spot of light about 2 m|m in diameter, which should be located five or six meters distant and in direct vertical and horizontal alignment with the instrument.

The normal spot of light should then be seen by the right eye and a long horizontal streak of light by the left eye, and should the

streak cut the spot, (Fig. 13) there would be no manifest vertical imbalance. If, however, the streak should appear above the spot, (Fig. 14) right hyperphoria would be manifest, while if below the spot, (Fig. 15) left hyperphoria would be manifest.

Fig. 13.

To measure the error, place the Stevens phorometer attachment in operative position, with right hand indicator set at naught on the red scale, (Fig. 6) and then rotate the prisms to such position as will cause the

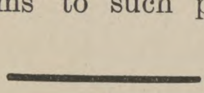


Fig. 14.

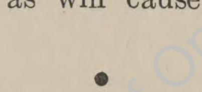


Fig. 15.

streak to cut the spot, whereupon the indicator co-acting with the red scale, will, according to Stevens, register the character and amount of manifest hyperphoria, "R.H." characterizing right hyperphoria and "L.H." left hyperphoria.

Next set the left hand indicator to naught on the white scale of the Stevens attachment

and the axis of the Maddox rod to horizontal position, (Fig. 5) and begin the test for lateral imbalances. The normal spot of light should then be seen by the right eye and a long vertical streak of light by the left eye, and should the streak cut the spot, (Fig. 16) there would be no manifest lateral imbalance. If, however, the streak should appear to the left of the spot, (Fig. 17) Esophoria would be

Fig. 16.

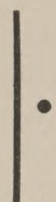


Fig. 17.

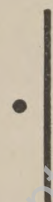


Fig. 18

manifest, while if to the right, (Fig. 18) Exophoria would be manifest. To measure the error, the Stevens prisms should be so adjusted as to cause the streak to cut the spot, whereupon the indicator co-acting with the white scale, will, according to Stevens, register the character and amount of manifest lateral imbalance, "E.S." characterizing Esophoria and "E.X." Exophoria.

Should the ten prism diopter range of the Stevens attachment prove inadequate, a double rotary prism unit may be placed in operative position before either the right or the left eye, with zero graduation vertical (Fig.3) and indicator set to ten on the outer scale for esophoria or ten on the inner scale for exophoria. The double rotary prism unit will, when so adjusted, add ten diopters to the reading of the esophoric, or exophoric, scales of Stevens respectively. In either instance the indicator on Stevens attachment should be returned to naught on the white scale and the test begun anew.

While a muscle test made with a Maddox multiple rod and the Stevens phorometer attachment, as already described, might quickly indicate the character and amount of an existing vertical or horizontal imbalance, such a test, owing to its binocular character, will neither locate the faulty muscle nor the consequent deviating eye. Therefore, this test is not definite and when employed should be followed by a monocular muscle test. Such a test is described in the next chapter.

CHAPTER VIII

Monocular Test of the Recti Muscles

Employing the Double Rotary Prism Units, Dark Room and Large Luminous Test Object.

AS an imbalance may lie in a faulty muscular poise of one or of both eyes, a test should be made of the muscular balance of each eye separately, otherwise the imbalance cannot be definitely located.

Such a test is known as a monocular muscle test, and is made in a dark room with a large luminous test object, located from five to six meters distant and in direct vertical and horizontal alignment with the phorometer when adjusted to operative position.

The best test object for this type of muscle testing is undoubtedly the Greek cross, contained in the dark room lantern shown in Fig. 12.

Should the observer be ametropic an accurate and well centered correction for the error should be in place while making these tests, and particularly so should it be hyperopic in character.

To test the lateral balance of the right eye, place a double rotary prism unit in operative position on corresponding side of instrument only, with zero graduation horizontal, (Fig. 2) and set the indicator to eight on the upper prism scale. The eight diopter prism equivalent thus obtained with base up, will displace the test object seen by this eye downward beyond the fusion range, and in consequence produce insuperable vertical diplopia. This prism

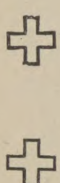


Fig. 19.

Fig. 20.

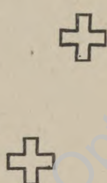


Fig. 21.

is known as the displacing prism in this test. Should the lower, or false object, seen by the right eye, lie directly beneath, or in the same vertical plane with the upper, or true object, seen by the left eye, (Fig. 19) there would be no manifest lateral imbalance of the right eye. If, however, the lower object should appear to the right of the upper object, (Fig. 20) right esophoria would be manifest, while

if to the left, (Fig. 21) right exophoria would be manifest, and in either instance, the amount of the imbalance could be correctly measured by placing a double rotary prism unit in operative position before the left eye, with zero graduation vertical (Fig. 3) and rotating the indicator outward or inward respectively from zero to that point on the scale wherein both objects would appear to lie in the same vertical plane, and then taking the reading accordingly. This second prism is known as the measuring prism in this test, and, when zero graduation is vertical, all required rotations of the indicator out, measure the esophoria, while those in, measure the exophoria of the other eye.

The lateral balance of the left eye should be tested in like manner, and the findings in each instance recorded for reference.

To test the vertical balance of the right eye, place a double rotary prism unit in operative position before this eye only, with zero graduation vertical (Fig. 3) and set the indicator to twelve on the inner prism scale. The twelve diopter prism equivalent thus obtained with base in, will displace the test object seen by this eye outward beyond the fusion

range, and thereby produce insuperable horizontal diplopia. Should the right hand, or false object seen by this, the right eye, lie in the same horizontal plane with the left hand or true object seen by the left eye, (Fig.

Fig. 22

22) there would be no manifest vertical imbalance of the right eye. If, however, the object to the observer's right should lie below the horizontal plane of the object to the left, (Fig. 23) right hyperphoria would be manifest,

Fig. 23

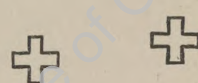


Fig. 24.

while if above, (Fig. 24) right cataphoria would be manifest, and in either instance, the amount of the imbalance could be correctly measured by placing a double rotary prism unit in operative position before the left eye, with zero graduation horizontal (Fig. 2) and rotating the indicator upwards or

downwards respectively from zero to that point on the scale wherein both objects would appear to lie in the same horizontal plane and then taking the reading accordingly.

When the measuring prism is in position with zero graduation horizontal, all required rotations of the indicator up measure the hyperphoria, while those down, measure the cataphoria of the other eye.

The vertical balance of the left eye should be tested in like manner and the findings in each instance recorded for reference.

This test may be made at the near point or reading distance in the same manner, by employing a minute spot of light or a small single black dot on a white card as a test object. When testing the muscles at the near point, an accurate and well centered reading correction should be in place if required, and the line of vision depressed about 15 degrees below the horizontal.

Should the 8. D. displacing prism employed base up as described, fail to suspend all action of the lateral muscles of the eye under test, a prism of somewhat higher power should be employed. This applies also to the 12. D. displacing prism employed base in when

testing the vertical balance, should it likewise fail in any instance to suspend all action of the vertical muscles of the eye under test.

If, upon the completion of a monocular muscle test, made in this way, at either the far or the near point, an imbalance should be shown to exist in one or in both eyes, the opposing muscles involved should be individually tested. This may be done by employing the duction test of the recti muscles described in the next chapter.

CHAPTER IX

Duction Test of the Recti Muscles

Employing the Double Rotary Prism Units, Dark Room and Large Luminous Test Object.

THE duction test of the recti muscles is based on Savage's physiologic principle, which teaches that when a prism is placed before the eye with base located accurately in, out, up or down, only that rectus muscle lying beneath the apex of the prism is stimulated to action, every other rectus muscle of both eyes remaining passive in so far as the effect of the prism is concerned.

By utilizing this fundamental principle, the independent contractile power, or range of disassociated action, of each rectus muscle may be accurately measured and its value relatively compared, whereupon the origin of an imbalance may be definitely determined.

This muscle test, like the former, should be conducted in a dark room with the aid of a large luminous test object, preferably the Greek cross, located five or six meters distant and in direct vertical and horizontal alignment with the phorometer.

An accurate and well centered correction for the observer's ametropia, if any, should be in place during these tests.

To test the adduction, or independent contractile power of the internal rectus muscle of the right eye, variable prism value with base out, or towards the temporal side, should be employed. A double rotary prism unit should therefore be placed before this eye with zero graduation vertical (Fig. 3) and the indicator rotated slowly outward from zero until the object is caused to double in the horizontal plane, at which point a reading from the prism scale should be taken. This test should be repeated several times, in order to obtain the highest prism value with base out which can be accepted without diplopia. The prism value thus obtained will indicate the right adduction, and should be so recorded.

To determine the abduction, or independent contractile power of the external rectus muscle of the same eye, variable prism value with base in, or towards the nasal side should be employed. The double rotary prism unit should therefore remain in the same relative position as before, with zero graduation vertical, but the indicator in this instance

should be rotated in the opposite direction, or inward from zero. This inward rotation of the indicator should be continued until horizontal diplopia occurs, as before, when a reading of the scale should be taken. Like the former, this test should be repeated several times, or until the highest prism value with base in which can be accepted without diplopia is obtained. This will indicate the right abduction, and should be so recorded.

The adduction and abduction are rated normally at about 3 to 1, or 24 to 8 prism diopters respectively. This, however, may vary considerably in different instances, but the rule usually applies.

To test the superduction, or independent contractile power of the superior rectus muscle of the right eye, variable prism value with base down should be employed. A double rotary prism unit should therefore be placed before this eye with zero graduation horizontal (Fig. 2) and the prism indicator rotated slowly downward from zero until the object appears to double in the vertical plane. The highest prism value with base down which can be accepted without diplopia will indicate the right superduction, and when found should

be so recorded. This will usually equal from 2 to 3 prism diopters but may fall as low as zero or run as high as 4 or 5 in some instances. This test should be repeated several times before the result obtained is accepted as final. Care should be exercised when making this test, as it is most sensitive, due to the limited range of independent action of the vertical muscles.

To determine the subduction, or independent contractile power of the inferior rectus muscle of the right eye, variable prism value with base up should be employed. The double rotary prism unit should therefore remain in the same relative position as before, with zero graduation horizontal, but the indicator in this instance should be rotated slowly in the reverse direction, or upwards from zero until the object appears to double in the vertical plane. The highest prism value with base up which can be accepted without diplopia will indicate the right subduction, and should be so recorded. This like the former will usually equal 2 or 3 prism diopters but may also fall as low as zero or run as high as 4 or 5 in some instances. This test also should be repeated several times, as

it is likewise sensitive and must be carefully conducted if an accurate estimate of the subduction is to be obtained.

When a test of each rectus muscle of the right eye has been made independently in this way, remove the double rotary prism unit from operative position and bring the one on the opposite or left side of the instrument up into operative place, and proceed in

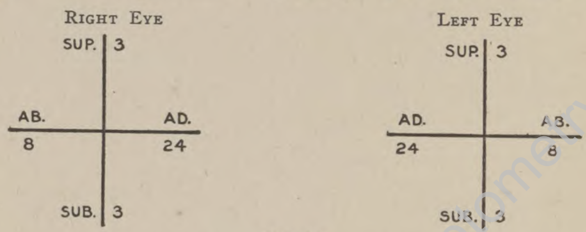


Fig. 25.

similar manner with a test of each of the four recti muscles of the left eye.

After testing each rectus muscle of each eye separately in this manner, a comparison of the results obtained should indicate the relative tendency of the visual axes, and, in the event of an imbalance, which muscle or muscles, of either or both eyes, as the case may be, are lacking in tone. Muscle exercise, prism lenses, or operative procedure may then be prescribed with definite knowledge

of the requirements in practically every instance.

Fig. 25 illustrates a case of perfect muscular balance, otherwise known as Orthophoria.

To illustrate the application of this test, take for example a case of lateral imbalance showing the following muscle findings expressed in prism dioptric values. Right adduction of 24 with an abduction of 8, (Fig. 26); left adduction of 18 with an abduction of 8, (Fig. 27). A comparison of these figures will

RIGHT EYE

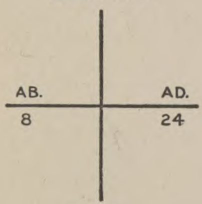


Fig. 26.

LEFT EYE

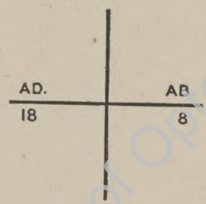


Fig. 27.

indicate an exophoria of approximately six prism diopters with a correspondingly weak left internus.

Likewise, in cases of esophoria, hyperphoria or cataphoria, definite muscle measurements made independently in this manner will usually indicate which muscle or muscles, as the case may be, are relatively too strong or too weak, and hence involved in the imbalance.

OBLIQUE MONOCULAR IMBALANCES AND THE UNIVERSAL DOUBLE ROTARY PRISM UNITS.

Oblique monocular imbalances, often manifesting false cyclophoria, being more readily measured and corrected by the use of a single prism with base located obliquely, than by the employment of two separate prisms for the same eye with bases placed 90 degrees apart, the universal double rotary prisms with their uniform adaptability to all meridians are most effective in cases of this sort.

They also provide ideal means for the simultaneous exercise of either of the lateral with either of the vertical muscles of the same eye in a most exact manner. This, as previously explained, is owing to the improved manner in which these double rotary prism units are now mounted, the fully graduated support and rotatable prism case with indicators, supplying exact means for locating the base of any derived prism value in any angular or oblique position before the eye. See "Exercise of two recti simultaneously," Chapter XII.

CHAPTER X

Monocular Test of the Oblique Muscles

Employing the Maddox Multiple Rods, Double Rotary Prism Units, Dark Room and Small Luminous Test Object.

IMBALANCES of the oblique muscles, giving rise to true cyclophoria, are detected by the combined use of two Maddox multiple rods and the double rotary prism units in the following manner:

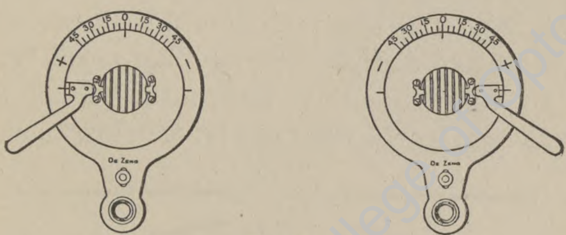


Fig. 28.

Darken the room and direct the observer's attention to a spot of light about two millimeters in diameter, located five or six meters distant, and in the same vertical and horizontal planes with the phorometer. An accurate and well centered correction for the observer's

ametropia, if any, should be in position when making these tests. Place a double rotary prism unit in operative position before the right eye with zero graduation horizontal, (Fig. 2) and rotate the indicator from zero upward to 8 upon the prism scale, thereby creating the equivalent of an 8 diopter prism with base up.

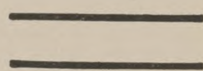


Fig. 29

Next place both Maddox rods in operative position with the axis of each set vertical, (Fig. 28). The observer should then see two separate and distinct streaks of light each lying in an approximately horizontal plane, the streak seen by the right eye lying below the one

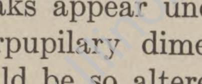


Fig. 30.

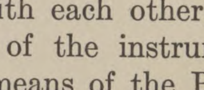


Fig. 31.

seen by the left eye. Should the ends of the streaks appear uneven with each other, the interpupilary dimensions of the instrument should be so altered by means of the P. D. adjusting screw as to bring them into vertical

alignment, neither one extending farther to the right or left than the other. Should the streaks appear parallel with each other, and both lie in a horizontal plane, there would be no manifest cyclophoria of the right eye, (Fig. 29).

Should the upper streak seen by the left eye appear horizontal, and the lower streak

Fig. 32.

Fig. 33.

seen by the right eye at an angle therewith, there would be cyclophoria of the right eye, and should the lower streak dip to the observer's left hand, (Fig. 30) the case would be one of right plus cyclophoria, whereas, right minus cyclophoria would be manifest should it dip to the observer's right hand, (Fig. 31).

With the displacing prism of 8 diopters placed base up before the observer's left eye, the streak seen by the left eye would appear to lie below the one seen by the right eye, and should the two streaks be parallel with each other and exactly horizontal, (Fig. 29) there would be no manifest cyclophoria of

the left eye. If, however, the upper streak should appear horizontal and the lower streak at an angle therewith, the left eye would be cyclophoric; the case being one of left plus cyclophoria should the lower streak dip to the observer's right hand, (Fig. 32) or left minus cyclophoria should it dip to the left hand, (Fig. 33).

The character of the cyclophoria may be readily determined and the amount measured by means of the indicators and graduated scales with which the Maddox rods are now provided. This is accomplished by rotating the respective rod to that position which will cause the tilting streak of light to appear horizontal, whereupon the position of the indicator with respect to the temporal or the nasal quadrants of the scale, as the case may be, will characterize the cyclophoria as plus or minus and signify the amount present in degrees.

These tests are particularly important in instances where the observer requires an astigmatic correction with cylinder axes lying in different oblique meridians. See "Ophthalmic-Neuro Myology" by Savage.

CHAPTER XI

Duction Test of the Oblique Muscles

Employing the Maddox Graduated Multiple White Rods, Dark Room and 10 m.m. Luminous Test Object.

THE range of independent action of the oblique muscles may be taken by means of the cycloduction test.

To make this test, place a Maddox graduated multiple white rod in operative position

Fig. 34.

before each eye with the axis of each horizontal, (Fig. 34) and employ a luminous test object about 10 m.m. in diameter, located five or six meters distant in the dark room and in direct alignment with the phorometer.

Should the observer be either ametropic

or heterophoric, or both, a suitable correction for same should be in place, as no action by the recti is desirable during these tests.

The observer should see but one broad vertical band of light, (Fig. 35) and to measure the duction range of the superior oblique of the right eye, the rod on the corresponding side of the instrument should be rotated slowly and steadily downward at its nasal end until the band of light begins to break, or assume the appearance somewhat of the letter X.


Fig. 35.


Fig. 36.


Fig. 37.

(Fig. 36) whereupon the position of the indicator with respect to the inner scale will denote the degree of right minus cycloduction.

Upon returning the rod to its former position for a moment, with axis horizontal and indicator at zero, it may be rotated downward at the temporal end until the vertical band of light breaks in the opposite direction,

(Fig. 37) whereupon the position of the indicator with respect to the outer scale will denote the duction range of the right inferior oblique, or the degree of right plus cycloduction.

The plus and the minus cycloduction of the left eye may be taken in like manner and the results obtained in each instance recorded for comparison. The duction range of the oblique muscles when taken in this way will average from 5 to 20 degrees of arc.

The Maddox Rods employed in this test should both be white, as described, otherwise the full fusion effort of the oblique muscles will not be obtained.

Heterophoria of whatever type may be fully investigated by making a thorough test of each muscle separately, as explained, for the origin of an imbalance can usually be determined through a relative comparison of the individual muscle values.

CHAPTER XII

Exercise of the Recti Muscles

Employing the Double Rotary Prism Units, Dark Room and Large Luminous Test Object.

THE recti muscles may be exercised effectively for the correction of an imbalance through the employment of the double rotary prism units in the following manner:

Should a duction test of the recti muscles made in a case of Exophoria, show for example, a right adduction of 24 prism diopters with an abduction of 8, and a left adduction of 18 with an abduction of 8, as described in Chapter IX (Figs. 26 and 27), the imbalance would be manifestly attributable to the inherent weakness of the left internus.

To exercise this weak left internal rectus muscle independently, a double rotary prism unit should be placed before the left eye only, with zero graduation vertical, (Fig. 3) and the attention of the observer directed with both eyes to a large luminous test object (preferably the Greek cross) located 5 or 6 meters distant in the dark room.

An alternately increasing and decreasing prism value should then be applied, with base opposite the muscle to be exercised. Therefore in this instance, the pinion should be so turned as to cause a rotation of the indicator from zero outward to 10 or 12 upon the prism scale, and then be reversed to zero again. This alternate rotation of the indicator outward from zero and back again, will cause the muscle to contract steadily as prism value is increased and then in turn relax as prism value is decreased, thereby producing a natural and effective exercise, which, as will be seen, may be applied independently to any rectus muscle of either eye as desired.

If, after exercising a muscle or muscles, as the case may be, in this way, three or four minutes a day for several days, a stronger prism can be accepted than at first, the range of exercise may be correspondingly lengthened and the practice continued until balance is obtained.

An accurate and well centered correction for refractive errors should be worn by the observer during the period of muscle exercise.

EXERCISE OF TWO RECTI SIMULTANEOUSLY.

Employing the Universal Double Rotary Prism Units, Dark Room and Large Luminous Test Object.

When a horizontal and a vertical rectus muscle of the same eye are to be exercised together, as for instance, the internal rectus and the inferior rectus, for the correction of an hyper-exophoria, a universal double rotary prism unit should be so placed before the heterophoric eye, that the base of the variable

Fig. 38

prism value to be employed in giving the exercise, will lie in the upper temporal quadrant. For instance, if, in the original oblique muscle test, the equivalent of a 6 diopter prism with base located at 200 degrees of the circle, was required to bring about balance in both the vertical and horizontal meridians, then, for the simultaneous exercise of the two recti muscles referred to, variable prism value

with base located approximately opposite, would be required. (Fig. 38).

While most forms of oblique monocular imbalance may be corrected by exercising first one of the weak recti muscles and then the other, until balance is restored in both meridians, nevertheless the application of variable prism value with base located obliquely as described, will be found both expedient and effective when giving exercise in cases of this kind.

The maximum prism value employed in giving muscle exercise should be somewhat less than that which will produce diplopia. Should the muscle, or muscles, show improvement following a few periods of exercise, of three or four minutes a day, the treatment may be continued until balance is obtained; otherwise it should be abandoned, as no form of exercise will correct every case of muscular imbalance.

CHAPTER XIII

Exercise of the Oblique Muscles

Employing the Maddox Graduated Multiple White Rods, Dark Room and 10 m.m. Luminous Test Object.

THE oblique muscles may be individually exercised by placing a Maddox graduated multiple white rod before each eye with axes horizontal (Fig. 34) and employing a luminous test object about 10 m.m. in diameter, located 5 or 6 meters distant in the dark room and in direct vertical and horizontal alignment with the phorometer.

Should the observer be ametropic or heterophoric, or both, a suitable correction for same should be in place, as the recti muscles should be at rest while exercising the obliques.

With both Maddox rods in position as stated, only one broad vertical band of light should be seen, (Fig. 35).

To exercise the superior oblique of the right eye, the index to the rod on the corresponding side of the instrument should be rotated slowly and steadily inward from zero to a point on the scale one or two degrees short of that which will break the single

vertical band of light, and then returned to zero again. The alternate rotation of the rod through this arc, will cause the muscle to contract steadily as the indicator departs from zero and then in turn relax as it approaches zero, thereby producing a natural and effective exercise, which, as will be seen, may be applied to the inferior oblique in the same manner, by rotating the rod in the opposite direction or outward from zero and back again.

The obliques of the left eye may be exercised by employing the rod on the corresponding side of the instrument in like manner.

This form of exercise, like that for the recti muscles, if beneficial after a few trials of three or four minutes a day, should be continued regularly until balance is obtained. Progress in the exercise of the obliques may be determined by the application of the cyclophoric test described in Chapter X., or by retaking the cycloduction for comparison with the original findings.

When exercising the oblique muscles white Maddox Rods should be employed, as explained in Chapter XI.

CHAPTER XIV

The Rotary Cross-Cylinder Unit.

Construction

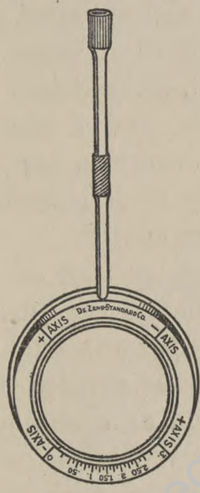
THIS alterable cylindrical lens system, devised by the writer, is for use in the detection and measurement of the different forms of astigmatism and may be employed independently for the correction of mixed, or in conjunction with spheres for simple or compound, astigmia.

It gives every cylindrical equivalent from 0 to 3. D. in both the plus and the minus quantities simultaneously, with their respective axes permanently located ninety degrees apart. When employed independently, it has the effect of a plus-minus cross cylinder only. When used in conjunction with spheres, a simple, compound or cross cylindrical equivalent is obtained, the result in each instance being governed by the strength of the sphere employed.

When the power of the supplemental sphere equals the power of the cylinder, as indicated on the scale, a plano cylindrical equivalent of

same character as the sphere but of double the indicated power of the cylinder is obtained.

When the power of the sphere exceeds the indicated power of the cylinder, a sphero-cylindrical equivalent of same character as the sphere is obtained, the cylindrical element



THE ROTARY
CROSS-CYLINDER UNIT

having double its indicated power, and the spherical element, its initial power less the indicated power of the cylinder.

When the power of the sphere is less than the indicated power of the cylinder, a plus-minus or a minus-plus sphero-cylindrical

equivalent is obtained, wherein the cylindrical element has double its indicated power and is of the same character as the sphere, while the spherical element is of opposite character and equal in power to the difference between the initial power of the sphere and the indicated power of the cylinder.

The unit consists of three plano cylinders, a fixed plus of 3. D. and two rotatable minus of 1.50 D. each, and a mounting provided with means for rotating the minus cylinders in reverse order with respect to each other about a common center.

The mounting, or case of the instrument, has an anular flange for retaining it in the cell of an optometer or a trial frame, in which it is adapted to be rotated for the location of axis, the same as a simple cylinder from the trial case. When the axes of all three cylinders are parallel with each other, as at zero, the system is neutral, but when they are at an angle with one another, following inverse rotation of the minus cylinders, the effect of a plus-minus cross cylinder is obtained, the power of which is proportional with the angle enclosed between the axes of the cylinders.

As the relative rate of inverse rotation of the minus cylinders is equal, the plus and minus cylindrical equivalents obtained, are confined to their respectively fixed right angle meridians. It will therefore be seen, that, as the minus cylinders are rotated away from that position in which their axes are parallel with the axis of the fixed plus cylinder, as at zero, both plus and minus cylindrical values are uniformly obtained in steadily increasing amounts until the maximum is reached, wherein the axes of the two minus cylinders become again parallel with each other and are at a right angle with the axis of the fixed plus cylinder.

The indicator registers all cylindrical equivalents obtainable from 0 to 3. D. in both the plus and the minus meridians simultaneously upon the focal scale located on the front of the instrument.

The axis of the plus cylindrical meridian and that of the minus, are also marked on the face of the instrument, and, as already explained, are permanently fixed, irrespective of the degree of rotation of the cylinders within the unit.

METHOD OF APPLICATION

In using the instrument, set the indicator at zero and place it in the front or revolving cell of the optometer, or trial frame, as the case may be, the same as any cylinder lens from the test case. By a partial rotation of the pinion head, turn on such cross cylinder power as may be desirable with which to begin the test. The entire instrument may be revolved before the eye for location of axis, after the manner of any trial cylinder lens. After an approximate axis is found, the cylindrical power may be altered, also the axis, until the required power and axis are obtained for the correction.

To quickly interpret the findings obtained with the rotary cross cylinder when used in conjunction with spheres, the following rule is given:

RULE

Double the cylindrical power indicated upon the focal scale of the instrument for the final cylinder, and deduct the same indicated power from the sphere. Prescribe plus cylinders with plus axis readings when plus spheres are used, or minus cylinders with minus axis readings when minus spheres are used with the instrument.

To illustrate the practical application of the unit, take for example, a case in which the final test shows 1. D. recorded on the focal scale and the plus axis graduation registering 90 on the scale of the trial frame, with a + 3. D. sphere used in conjunction therewith. As the one diopter indicated on the focal scale, would represent a plus cylindrical quantity of one diopter in the horizontal meridian and a minus cylindrical quantity of the same amount in the vertical meridian, the addition of the + 3. D. sphere, would give + 4. D. for the horizontal meridian and + 2. D. for the vertical meridian, being the equivalent of a sphero-cylinder of + 2. S. + 2. C. Axis 90.

Should the instrument be used without a supplementary sphere, a cross-cylinder of such power and axes as indicated may be prescribed, or the equivalent in a plus-minus or a minus-plus sphero-cylinder.

To further illustrate, take for example an ametropic eye having one diopter of hypermetropia in the vertical meridian with two in the horizontal, and requiring for its correction a sphero-cylinder of + 1. S. + 1. C. Axis 90. The strongest simple sphere

which such an eye could accept with benefit would be a + 1.50, which would over-correct the vertical meridian .50 and under-correct the horizontal the same amount. With such a sphere in place, the strongest simple cylinder which could be fitted with benefit would be a .50, the correct cylinder of + 1. D. with axis at 90, only being accepted following the reduction of the sphere to + 1. D.

Should the rotary cross-cylinder unit be used in the above case, in conjunction with the + 1.50 sphere referred to, the exact correction could be obtained at once by locating the plus axis mark at 90 on the trial frame scale, and then rotating the indicator from zero to one half diopter on the focal scale of the instrument. The rotary cross-cylinder unit being a plus-minus quantity at all times, would, in this instance, deduct .50 from the vertical meridian and add .50 to the horizontal simultaneously, thereby altering the original sphere from + 1.50 in all meridians, to + 1. D. in the vertical and + 2. D. in the horizontal meridian. The rule for doubling the indicated power for the final cylinder, and deducting the same

indicated power from the sphere, for the final sphere, would, if applied in this instance, convert the .50 registered on the focal scale of the instrument to 1. D. for the final cylinder, and reduce the 1.50 sphere to 1. D. for the final sphere. By prescribing plus cylinders with plus axes when plus spheres are employed, the final prescription of + 1. S. + 1. C. axis 90 would be correctly obtained.

APPLICATION OF UNIT WITH FOGGING METHOD

When used in conjunction with the fogging method of testing astigmatic eyes, the plus axis marking on the face of the rotary cross-cylinder unit should be set parallel with the first radiating lines on the astigmatic chart which clear, as the fogging spherical lens is reduced in strength. Sufficient cylinder power should then be turned on, by rotation of the pinion, to shade the originally clear lines in harmony with the opposite, or originally blurred lines, which will have been cleared in the same relative proportion that the clear lines will have been shaded by the action of the instrument as described. An exact correction for the astigmatism can be quickly obtained in this way, as an under correction

will leave the originally clear lines still the more distinct, while an over correction will render them less distinct than the originally blurred lines. When the instrument is finally so adjusted for both focal strength and axis, that all the radiating lines appear uniform while slightly shaded, a small reduction in the power of the fogging lens, will clear every meridian uniformly and give the final correction. By use of the rule the findings in every instance may be quickly reduced to the simplest practical prescription form.

Date Due
